Perception of multiple moving objects through multisensory-haptic interaction : is haptic so evident for physical object perception ?

Maxime Houot, Annie Luciani, Jean-Loup Florens

3rd International Conference on Enactive Interfaces

ENACTIVE / 06

ENACTION & COMPLEXITY

November 20-21, 2006

Montpellier, France

PROCEEDINGS

Information Society Technologies

ENACTIVE Enactive Interfaces

Université Montpellier 1

Perception of multiple moving objects through multisensory-haptic interaction: Is haptic so evident for physical object perception?

Maxime Houot[1], Annie Luciani[1] & Jean-Loup Florens[2]
[1]ICA Laboratory, INPG-Grenoble, France
[2]ACROE, Grenoble, France
maxime.houot@imag.fr

This paper deals with the perception of objects numerosity from sounds and/or images and/or haptics. We used Virtual Reality to realise a Virtual Pebble Box: the experimental context corresponds to a box containing hard mobile objects we can handle with a rigid stick. The state of the art deals with the perception of stimuli numerosity, whereas we wanted to study the perception of objects numerosity from their stimuli. For example, Koesling et al. (2004) show that the linking of dots by line segments leads to an underestimation of their number. Allik and Tuulmets (1991) propose a similar result: dots area influences dots numerosity judgments. Objects identification is not broached, except by Essl et al. (2005). They show that participants estimate fairly well the number of solid objects with which they interact, and the control they have in a noisy interaction.

From these results, we wanted first to isolate the modality that allows to infer the kind of environment explored, and to cover the scale of confinement (numerosity being related to a confined space) to study the perception of several. But these two experimentations seemed premature compared to the state of the art. Consequently, a preliminary upstream experimentation is necessary, particularly with seen of very surprising reactions from subjects manipulating two different implementations of Virtual Pebble Box in an explorative test session performed at INPG in collaboration with the University of Lund (2005). In that aim, a not quantifying experimentation has been set-up allowing us to analyse participants comments on what they are experiencing while manipulating a Virtual Pebble Box with a high fidelity haptic ©ERGOS Technologies device (www.ergostechnologies.com).

The results leads to a surprising conclusion: the perception of mobile objects, with haptics only and in multisensory situation, is not so trivial, and exhibits strong stable surprising paradoxes. It allows us to ask new questions on the multisensory perception of moving objects.

Method

The 2D Virtual Pebble Box used is composed by a circular box containing 8 mobile masses more or less rigid, in interaction of collisions more or less visco-elastic and with 1 more or less rigid mass (the manipulator) controlled by the ERGOS device. 6 participants manipulated 54 different models of virtual Pebble Box: 9 physical parameters sets for the Pebble Box containing always 8 masses * 6 different sensory feedbacks.

The set of 9 physical parameters was:

- a combination of 3 different interactions: (1) Hard collisions, small viscosity; (2) hard collisions, medium viscosity; (3) soft collisions, medium viscosity;
- with 3 different size of masses: (1) 8 big masses, 1 small manipulator; (2) 8 medium masses, 1 medium manipulator; (3) 8 small masses, 1 big manipulator.

The 6 sensory feedbacks were: (1) only haptic, (2) haptic + audio, (3) haptic + "ball-like visual rendering", (4) haptic + "continuous matter - like visual rendering", (5) haptic + "ball-like visual rendering" + audio, (6) haptic + "continuous matter - like visual rendering" + audio. Figure 1 shows the same Pebble Box with the two different visual rendering: "ball-like visual rendering" on the left and "continuous matter - like visual rendering" on the right. In this figure, the Pebble Box is composed of 8 big masses (represented in yellow on the left), and one small mass for the manipulator (represented in green on the left). The participants manipulated the Virtual Pebble Box as long as they want. They were invited to comment freely the scene they identified, with their own vocabulary. The experimentation was filmed.

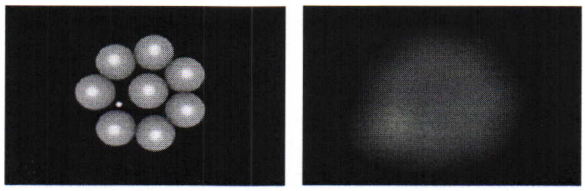

Figure 1. Left: "ball-like visual rendering". Right: "continuous matter - like visual rendering".

Results

The perception for the 9 different Virtual Pebble Box with only the haptic feedback, leads mainly the participants to conclude either to the perception of only one object (among 8) or to a kind of continuous environment, according to the value of the physical parameters. That is the biggest paradox, because the scene is objectively composed neither by only one object, nor by a continuous matter. The following examples illustrate this paradox:

a. Example 1:

Description: 8 big and hard masses; one small and hard manipulator.

Result: With only the haptic, the 6 participants detected only 1 object among 8.

b. Example 2:

Description: 8 medium and soft masses; one medium and soft manipulator.

Result: With only the haptic, the 6 participants perceived a continuous environment composed of a single matter.

When other modalities are added, the paradox is attenuated but it does not change fundamentally. These results are even more surprising as 4 participants knew perfectly well the scene, as they were their designers: they concluded completely differently from what they perfectly knew in details objectively.

Main conclusions and perspectives

1. The analysis of the results shows that the estimation of the number of objects is not a spontaneous focus when we manipulate a Virtual Pebble Box. 4% of the manipulations lead to a numeration.

2. The difference between "One / Single" and "Several" is not so easy: About 6% of the manipulations lead to a clear perception of several objects.

3. The judgement of the kind of environment (one object vs. continuous environment) seems to be a more natural task. But what are the parameters that influence this perception? As shown in *Example 2*, the elasticity of the collisions seems to play an important part.

With seen these results, we may ask ourselves if haptic is so evident in the perception of moving material objects. It is a surprising discovery opening new issues in the cognitive field. In addition, multisensory returns do not change radically the conclusions. In the best of the cases, the visual rendering reduces the paradox.

Several prospects are suggested from these observations:

1. Why do participants identify only 1 object between 8 identical (as in *Example 1)*? Are there minimal sensory-haptic conditions allowing us to infer a given moving object?
2. Comparing the models leading to the perception of a continuous environment with models of continuous environment could help us to understand the phenomena of *example 2.*

References

Essl, G., Magnusson, C., Erikson, J., & O'Modhrain, S. (2005). Towards evaluation of performance, control, and preference in physical and virtual sensorimotor integration. 2nd International Conference on Enactive Interfaces, 17-18 November, Genoa, Italy.

Jallik, J., & Tuulmets, T. (1991). Occupancy model of perceived numerosity. *Perception & Psychophysics, 49(4),* 303-314.

Koesling, H., Carbone, E., Pomplun, M., Sicchelschmidt, L., & Ritter, H. (2004). When more seems less - non-spatial clustering in numerosity estimation. Early Cognitive Vision Workshop ECOVISION 2004, 28 May 1 Juin, Isle of Skye, UK.

Perception of multiple moving objects through multisensory-haptic interaction:

Is haptic so effective for physical object perception?

Maxime Houot[1], Annie Luciani[1] & Jean-Loup Florens[2]

Laboratoire ICA
Informatique et Création Artistique
Grenoble, France

[1] ICA Laboratory, INP-Grenoble (France)

ACROE

[2] ACROE, Grenoble (France)

ENACTIVE
Enactive Interfaces

What is an object?

This question emerge of the analysis of the subjects commentaries having taken part in the experimentation "Virtual Pebble Box" carried out at the ICA Laboratory (Grenoble) within the framework of the European network of excellence "Enactive Interfaces".

In order to study the perception of objects numerosity from sounds and/or images and/or haptics, we used Virtual Reality to realise a Virtual Pebble Box. It was composed of:

- a 2D circular box
- 8 mobile masses (the agglomerate) more or less rigid, in interaction with
- 1 more or less rigid mass (the manipulator) controled with
- a high fidelity haptic ©ERGOS Technologies device (www.ergostechnologies.com).

We used the physical modeller CORDIS ANIMA to create our models.

6 subjects manipulated 54 different models of virtual Pebble Box: 9 models with different physical parameters sets for the Pebble Box always containing 8 masses * 6 different sensory feedbacks. They freely commented on what they felt. This poster bring back the strong paradoxes which emerge of these comments.

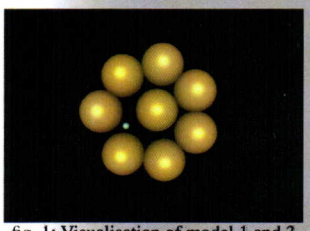

fig. 1: Visualisation of model 1 and 3

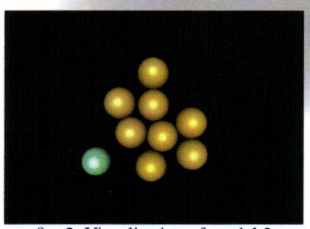

fig. 2: Visualisation of model 2

Experimentation 1

Description:

1 soft manipulator of average size (in green on fig. 1) in interaction with 8 soft masses of average size (in yellow on fig. 1). The viscosity is medium.

Perception:

Subjects perceived a kind of paste.
They felt something continuous, made of only one material.

Conclusion:

The subjects perceptions correspond to a continuous medium whereas the scene is composed by 8 identical masses.

Three of the nine models lead the subjects to this type of perception.

Experimentation 2

Description:

1 hard manipulator of small size (in green on fig. 2) in interaction with 8 hard masses of large size (in yellow on fig. 2). The viscosity is medium.

Perception:

Subjects perceived ONE object.

Conclusion:

The subjects perceptions correspond to only ONE object whereas, objectively, the scene is composed by 8 identical hard masses.

Three of the nine models lead the subjects to this type of perception.

Experimentation 3

Description:

1 hard manipulator of average size (in green on fig. 1) in interaction with 8 hard masses of average size (in yellow on fig. 1). The viscosity is low.

Perception:

Subjects perceived either one object or several objects.

Conclusion:

This is the only model where, sometimes, subjects perceived clearly several objects.

Two other models led the subjects to perceive the scene in an intermediate way between ONE object and a continuous medium, but in different ways.

Conclusion

The analysis of the results shows that the estimation of the number of objects is not carried out spontaneously when we manipulate a Virtual Pebble Box: about 4% of the manipulations lead to a numeration. The judgement of the type of environment (One object Vs continuous environment) seems to be a task carried out more naturally, even if the scene is never composed by one object or a continuous environment. As perceptions evolved from a medium to one object, it could be interesting to isolate the parameters controlling our perceptive scale going from a continuous medium to one or more objects.

The difference between "One / Single" and "Several" is not so easy: about 6% of the manipulations lead to a clear perception of several objects.

Finally, according to the subjects perceptions during experimentation 1, we may ask ourselves which are the minimal conditions of a haptic interaction allowing us to infer the presence of an object?

With seen these results, we may ask ourselves if haptic is so effective for the perception of moving objects. It is a surprising discovery opening new issues in the cognitive field.